5528

Fe^{2+}-Mg PARTITIONING BETWEEN OLIVINE AND MARTIAN BASALTIC MELTS

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Introduction: The partitioning of elements between olivine and liquid is key to understanding igneous processes in mafic and ultramafic systems [1]. The landmark study of Roeder and Emslie [2] concluded that the olivine (ol)-liquid (liq) exchange coefficient, $K_{D,Fe^{2+}-Mg} = (FeO/MgO)^{ol} / (FeO/MgO)^{liq}$ (by weight), is 0.30 ± 0.03, independent of temperature (T) and liquid composition. Subsequent work [3] has shown a dependence on liquid composition, but the canonical value of 0.30 is still widely used in both terrestrial and Martian applications [e.g., 4, 5]. Here, we use previously published experiments on bulk compositions relevant to Martian magmas to determine the appropriate $K_{D,Fe^{2+}-Mg}$(s) for Martian systems; we then use this value to test whether any of the ol-phyric shergottites represent liquids.

Experiments on Martian Compositions: One-atm experiments on model Martian compositions provide the tightest constraint on $K_{D,Fe^{2+}-Mg}$ because T and oxygen fugacity (fO_2) are well known, allowing us to use [6] to predict the amount of ferrous iron present in each liquid. The median of 17 published 1-atm experiments yields $K_{D,Fe^{2+}-Mg}$ = 0.354 ± 0.008 (error is one mean absolute deviation, MAD). There are higher pressure (P) experiments on model Martian compositions, but their fO_2s are less well constrained. High-P experiments in graphite capsules are reducing [7], but Fe^{3+} still materially affects estimates of $K_{D,Fe^{2+}-Mg}$; correcting for the Fe^{3+} using [6, 7] increases $K_{D,Fe^{2+}-Mg}$, on average, by 0.016. We see no strong correlations of $K_{D,Fe^{2+}-Mg}$ with liquid or ol composition for the high or low-P experiments and a weak increase in $K_{D,Fe^{2+}-Mg}$ with increasing P. A marked increase in $K_{D,Fe^{2+}-Mg}$ for high-P experiments at $T < \sim 1150$ °C is likely due to lack of equilibrium. Accepting high-P experiments with $T > 1150$ °C leads to a median $K_{D,Fe^{2+}-Mg}$ of 0.369 ± 0.024 (MAD), higher than the 1-atm experiments but notably higher than the canonical value of 0.30 [2]. Combining 1-atm. and high-P, high-T experiments yields a median $K_{D,Fe^{2+}-Mg}$ of 0.360 ± 0.013 (MAD), close to the recently reported value of 0.35 ± 0.01 [8], which was obtained without correcting for Fe^{3+} in the liquid.

Olivine-Phyric Shergottites: Using $K_{D,Fe^{2+}-Mg}$ = 0.30 leads to the result that none of the ol cores in ol-phyric shergottites is in equilibrium with liquids equivalent to their bulk. Applying our $K_{D,Fe^{2+}-Mg}$ to these shergottites leads to the possibility that Y980459, NWA 5789 and 2990 are liquid compositions (others are not), identical to the results of Filiberto and Dasgupta [8]. Accounting for Fe^{3+} in the liquid also allows us to constrain plausible fO_2s during cooling when independent measures are unavailable or not yet determined; e.g., if the olivines in NWA 2990 are in equilibrium with a liquid whose composition is that of the bulk meteorite, crystallization must have occurred under reducing conditions where the $Fe^{3+}/\sum Fe$ is small, ~IW + 0.5 at 1 atm or IW + 1 at 1 GPa.

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5173

EXPLORING XRF AS A NEW TECHNIQUE FOR BASIC METEORITE CLASSIFICATIONS

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Current Classification Methods: In the 2010/2011 season, the Antarctic Search for Meteorites (ANSMET) collected around 1200 meteorites. These will all be classified over the next 2 years, according to the U.S. Federal Regulation on Antarctic Meteorites [1], by the curatorial staff at the Smithsonian Institution's National Museum of Natural History. The vast majority of the meteorites collected in Antarctica are equilibrated ordinary chondrites and the current method employed for their identification is that of visual examination combined with oil immersion of olivine grains. This technique requires that a small amount of each meteorite be powdered, sieved, and then examined in refractive index oils under a petrographic microscope. This is a timely process and the Smithsonian's main goal is to be able to "separate the approximately 10% of meteorites that deserve further scientific study" [1].

XRF: The Monnig Meteorite Collection deals with many requests from the general public for meteorite identification. The vast majority of these samples are industrial slag. The newly purchased Bruker handheld XRF will be used to analyze these samples to confirm that their composition is not meteoritic.

The goal of this study is to explore XRF as a new technique for meteorite identification. In this preliminary study we will present data on the first two parts of this study (1) estimating the Ni-content of iron meteorites (2) examining previously classified ordinary chondrites to establish a calibration technique for unknowns. The eventual aim is to see if the XRF technique outlined here can be used to distinguish LL, L, and H chondrites from one another, to provide an alternative streamlined process to oil immersion.

Methodology: All meteorites will be analyzed on the Bruker Tracer III-SD handheld XRF system at Texas Christian University. For part (1) only meteorites from the Monnig Meteorite Collection with a published Ni content were selected for analysis. All Ni contents were taken from [2]. A minimum of three analyses were taken for each sample. The number of counts for Ni Kα were tabulated each time and a calibration curve was constructed. Previously classified ordinary chondrites were selected from the Monnig Collection for part (2) of the study. Twenty meteorites of each ordinary chondrite group (H, L, LL) will be measured.

Preliminary Results: Initial results relating Ni Kα counts to Ni content of iron meteorites show that these two components do appear to be directly related and no further reduction of the data (into percentage Ni) is required. The calibration curve constructed from the preliminary data has an R^2 value of 0.94.

At the time of writing, only five H, L, and LL meteorites have been analyzed on the XRF. While there appear to be some differences between the ordinary chondrite groups, there is currently not enough data for statistical analysis to see if these differences are significant enough to allow their identification.

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